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Predictive Diagnostics for Pump Seals: Field Trial Learnings

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Authors Bios

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Senior Reliability Engineer

- At INEOS from 2014-2016
- Special interest in rotating equipment & pump sealing
- Certified Lubrication Specialist (CLS)
- Bachelor's Degree of Mechanical Engineering from Michigan State University

Matthew Miller

Field Service Engineer

- Started at John Crane in 2015 in their engineering development program
- Joined Predictive Diagnostics team as Field Service Engineer in 2016
- B.S. in Mechanical Engineering from Brown University



Abstract

Predictive maintenance provides obvious benefits to the industry in terms of cost savings and efficiency, but today many critical assets like pumps are not monitored.

A system based on artificial intelligence techniques for automatic fault classification has been developed. Diagnostic algorithms for key failure modes are tracked concurrently, and a pre-programmed fault tree and Bayesian Network Model are used to infer the most likely future failure modes and root causes. This case study details the results of an early field trial.

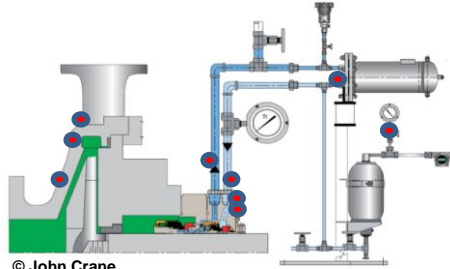


Background

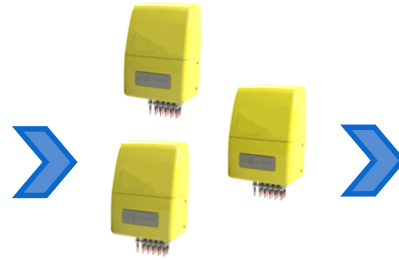
- A predictive diagnostics capability has been developed based on proprietary research and seal expertise
- Aligns with industry trends to expand the use of data to drive operational efficiency
- Solution is under development – expanding field trial installed base



Integrated System Architecture



Sensors



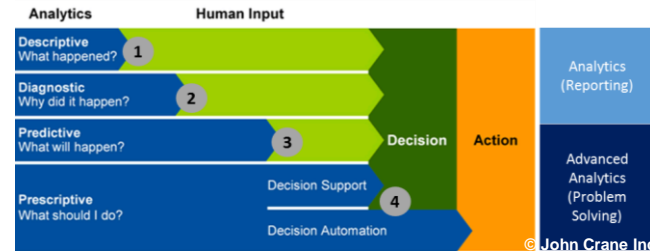
Hardware



Data



User Interface/
Remote Monitoring



Analytics



Condition Monitoring vs. Predictive Diagnostics

- Condition Monitoring
 - Records data
 - Typically not continuous
 - Interpretation left to trained expert
 - By itself, not predictive in nature
- Predictive Diagnostics
 - Continuous data collection
 - Converts data to actionable information
 - Can predict failures, including incipient failures not identifiable through traditional monitoring
 - If failure is not predictable, root cause analysis can be used to diagnose cause (e.g. procedural issue, process upset)



Failure Modes

- Automatic detection of failure modes, including:
 - Loss of interface lubrication / face wear
 - Low barrier flow
 - High leakage
- Software baseline established and all failure modes tracked simultaneously
- Estimation of remaining useful life
- Projection of probable future failure modes when an incipient failure is detected
- Initial alpha trial following years of test-lab R&D in UK, US and China



Field Trial – Target Asset

- Plant target MTBF ~ 4 years
- Focused on one bad actor with less than 1 year MTBF
 - Single-stage, between-bearing, radially split pump
 - API Plan 21/52
 - Benzene/Cumene process
- Limited monitoring in-place
 - No telemetry to DCS
 - Manual walkaround – visual inspection
 - Periodic vibration monitoring via hand-held data collection



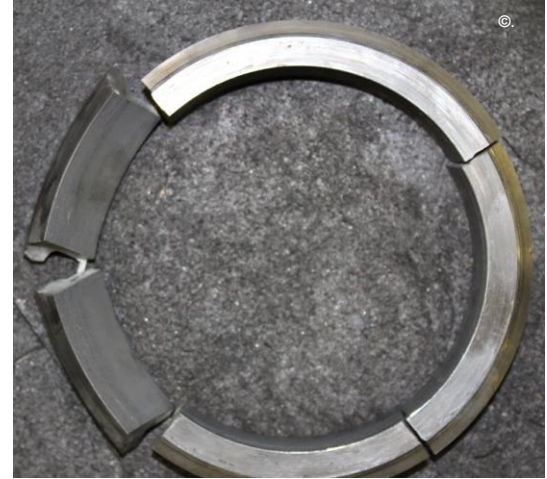
Field Trial – Solution Deployed

- Pump and seal instrumented specific to pump type and seal support plan
- Data acquisition units communicate with server on site via WiFi
- Remote monitoring of system established



Results – Startup Failure Detected

- System commissioned and pump brought online 20 May 2015
- Catastrophic seal failure occurred at both ends within 1 minute of startup
- Failure detected via remote monitoring by supplier
- Alert sent to plant operators

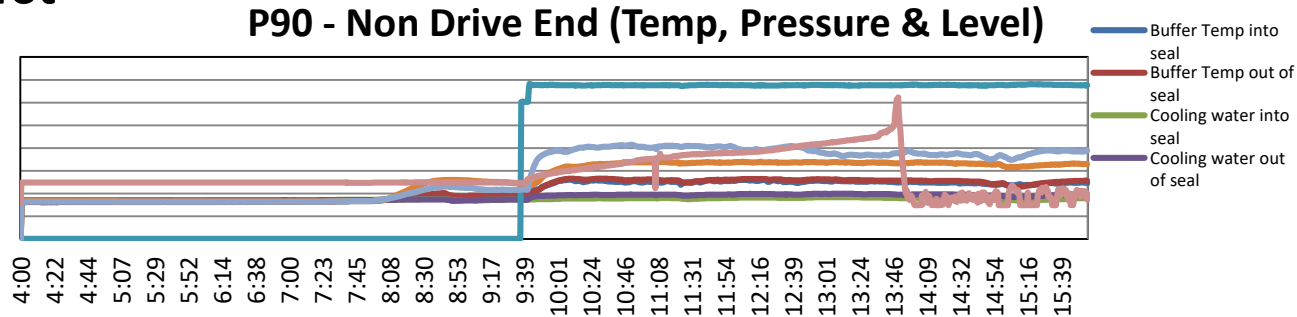


Initial Conclusions and Recommendations

- Root cause found to be start-up procedure
 - A/B pumps running in parallel at the same time before shutting one pump down
 - Check valve slammed shut causing water hammer through shut-down pump
- Had data to inform discussions with operations
 - Shut down running pump first, and almost simultaneously bring other pump up
- Procedure altered for next startup – success!
- Seals replaced and pump brought back online on 24 June – trial resumed...

Results - Additional Faults Identified on Restart

- Incipient failures not previously identified were detected
 - High leakage on inboard seals
 - Transient abrasive face wear
 - Low or no buffer flow - automatically detected after startup
 - Loss of interface lubrication resulted in repeated NDE seal face contact



More Conclusions and Recommendations

- After pump brought back online ~24 June '15 NDE seal shows constant signs of distress...
- Correcting buffer flow reduces seal face contact and wear
 - Cooling water side fouled due to high delta T
 - Buffer flow low or reduced due to possible vapor lock
- High leakage on inboard seals - fills up buffer pots with process



Lessons Learned – Value of Predictive Diagnostics

- Continuous data collection is critical to identifying transient phenomena that cannot be predicted
- Multiple faults may be developing in bad actor pumps
 - Without individual failure mode tracking the underlying issues cannot be disaggregated and corrected
- In this application, the benefits of applying predictive diagnostics are:
 - Continuous monitoring enables diagnosis of transient events
 - Failure mode algorithms can identify multiple incipient failures
 - Remote monitoring supports plant personnel in resolving issues

